63rd Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) Benchmark stock assessment for Ocean Quahog

Reviewer Report to the Centre for Independent Experts on the Ocean Quahog Stock Assessment Review (SARC 63) held February 21-23, 2017 in Woods Hole, Massachusetts

By:

Dr Anthony M. Hart
Western Australian Fisheries and Marine Research Laboratories
39 Northside Dr Hillarys
WA 6025
Australia

March 2017

Table of Contents

Executive Summary

- This report is an independent peer review of the benchmark assessment for ocean quahog, presented at the 63rd SARC meeting, at Woods Hole, Massachusetts.
- Terms of Reference (TORs) with respect to the ocean quahog assessment were all met and I accept the conclusions of the Working Group stated in the assessment.
- Catch and discard levels are well characterised, fishery independent survey trend data exists for almost the entire duration of the fishery, ecological and demographic parameters are reasonably informed, and an appropriate population dynamics model was developed, compared with previous models, and used to evaluate current and future stock status of ocean quahog under a wide range of sensitivity scenarios to uncertainty in demographic and harvest parameters.
- Additionally, a comprehensive management strategy evaluation (MSE) was undertaken to develop new biological reference points (BRPs) based on knowledge of ocean quahog dynamics, rather than the use of proxies from other species. According to the new BRPs, the stock is not currently overfished and overfishing is not occurring.
- The main weakness of the assessment stems from the difficult problem in obtaining robust estimates of absolute biomass when fishing mortality (F) is not high enough to influence the biomass trend. This results in a high uncertainty in the scale of the biomass estimates. The problem was partially dealt with by evaluating stock status in terms of ratios and trends of current F and spawning biomass to unfished levels.
- It is unlikely that any signal will be available from the biomass trend into the future at such low levels of F, unless serial depletion is occurring and eventually the high density patches are exhausted. This potential issue was discussed, as it has been in previous assessments of this species, and should remain as an open question at all future benchmark assessments for this fishery.
- The main potential improvement in the assessment will come from a more informed size-structure, and therefore abundance index, derived from the fishery independent dredge survey. To capture this however, will require further modifications in dredge design and dredge deployment procedures to access the smaller individuals in the population. It would also be prudent to review the statistical procedures for deriving the abundance index, if further survey changes are contemplated. Detailed suggestions are provided in my response to TOR 2.
- It must be noted that difficulties and weaknesses in the assessment in no way affect the clear conclusion of stock status, i.e., the stock is not currently overfished and overfishing is not occurring. This conclusion needs to be kept in mind when determining the priority and/or urgency of research recommendations.

Terms of Reference

Terms of reference (TORs) for this review were outlined in the SOW. Specifically, the Review Panel shall assess whether or not the SAW Working Group has reasonably and satisfactorily completed the following actions.

1. Estimate catch from all sources including landings and discards. Map the spatial and temporal distribution of landings, discards, and fishing effort, as appropriate. Characterize the uncertainty in these sources of data.

2. Present the survey data being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, length data, etc.). Use logbook data to investigate regional changes in LPUE, catch and effort. Characterize the uncertainty and any bias in these sources of data. Evaluate the spatial coverage, precision, and accuracy of the new clam survey.

3. Describe the relationship between habitat characteristics (e.g., benthic, pelagic, and climate), survey data, and ocean quahog distribution, and report on any changes in this relationship.

4. Evaluate age determination methods and available data for ocean quahogs to potentially estimate growth, productivity, and recruitment. Review changes over time in biological parameters such as length, width, and condition.

5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR 4, as appropriate) and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results and previous projections.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, FMSY and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to any new model or models developed for this peer review.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-6).

8. Develop approaches and apply them to conduct stock projections.

a. Provide numerical annual projections (5 – 50 years) and the statistical distribution (e.g., probability density function) of the OFL (overfishing level), including model estimated and other uncertainties. Consider cases using nominal as well as potential levels of uncertainty in the model. Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

c. Describe this stock's vulnerability (see "Clarification of Terms used in the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports. Identify new research recommendations.

1 Background

The 63rd SARC (Stock Assessment Review Committee) meeting was held in the Aquarium Conference Room at NOAA's Northeast Fisheries Science Center in Woods Hole, MA from 21-23 February, 2017 to review the stock assessment for Ocean Quahog. The review committee (SARC Panel) consisted of three scientists appointed by the Centre for Independent Experts: Martin Cryer, Mike Bell and Anthony Hart, and was chaired by Edward Houde, a member of the Mid-Atlantic Fishery Management Council's Scientific and Statistical Committee. The Panel reviewed the benchmark stock assessment of the Ocean Quahog (*Arctica islandica*), guided by the SAW 63 Terms of Reference and the Statement of Work.

The SARC Panel was assisted by staff of the NEFSC, including James Weinberg and Sheena Steiner. Supporting documentation for the Ocean Quahog assessment was prepared by the Ocean Quahog SAW 63 Working Group. Working Group (WG) members are identified in the stock assessment report and in Appendix 5 of this report. Presentations at the meeting were made by lead assessment scientist Dan Henning (NEFSC) and coordinated by Working Group Chair Larry Jacobsen (NEFSC). Dan Henning, Larry Jacobsen and Jim Weinberg drafted the SARC 63 Assessment Summary Report.

Thanks to Toni Chute and Alicia Long (NEFSC staff) who served as meeting rapporteurs. Twenty four people participated in the SARC 63 meeting (Appendix 3). Thanks to Chris Legault (NEFSC) for able assistance with editing and revising the SARC 63 Assessment Summary Report.

On day 3 of the SARC Review, the SAW Chair and Lead Scientist informed the Panel about adjustments to the retrospective analysis. The Lead Scientist presented a revised figure of retrospective patterns in "spawning output," that indicated lesser shifts in scale than the original figure, but the same lack of retrospective trends over time. No serious retrospective behaviour was indicated and the adjustments and corrections will have no substantial or consequential effects on the assessment outcome.

2 Review of activities and SARC process

Two weeks prior to the meeting, assessment documents and supporting materials were made available to the SARC Panel via a server on the NEFSC website. The Panel met with James Weinberg and Russell Brown (NEFSC) on the morning of February 21, 2017, before the meeting commenced to review the meeting agenda, reporting requirements, and meeting logistics. During the SARC meeting, background and working documents were available electronically and in print.

The meeting opened on Tuesday, February 21, with welcoming remarks and presentation of the agenda by Jim Weinberg and Ed Houde. Participants and audience members introduced themselves. Following introductions, sessions on February 21 and the morning of February 22 were devoted to presentation and discussion of the Ocean Quahog assessment. The SARC Panel and NEFSC staff met in the afternoon of February 22 to review and edit the Assessment Summary Report that was drafted by NEFSC staff. The SARC Panel worked privately on February 23 to draft its individual reports and the SARC 63 Panel Summary Report. In its February 23 work, the Panel developed consensus points for the Terms of Reference as well as observations on the SARC process. Individual panellists used consensus points to draft sections of the Panel Summary Report, which were compiled and edited by the SARC chair.

The SARC 63 Panel Summary Report was completed by correspondence. It evaluates response by the SAW to each ToR that had been addressed by WG. The SARC Chair compiled and edited the draft Panel Summary Report, which was shared with the Panel for contributions, editing, and final review before being submitted to the NEFSC.

Additionally, each of the Panellists drafted and submitted an independent reviewer's report to the Center for Independent Experts and to the NEFSC.

3 Summary of Findings

3.1 TOR 1: Commercial Data

Estimate catch from all sources including landings and discards. Map the spatial and temporal distribution of landings, discards, and fishing effort, as appropriate. Characterize the uncertainty in these sources of data.

This TOR was completed. The ocean quahog is a well-managed resource with auditable catch records that have been collated since the inception of the fishery. Estimates of total harvest include allowances for incidental mortality of quahog from interactions with the fishing gear as well as discards. The allowances are supported by theoretical or empirical information and are considered reasonable, as well as being a non-issue in this fishery as they are a small percentage of the total harvest. Estimates of landings were assumed accurate due to the ITQ and cage tag systems. There also appears to be no economic incentive to misrepresent catch as the quota is not being caught due to a saturated market. Bycatch of ocean quahog from other fisheries was considered zero as it is not vulnerable to other gear.

Distribution of landings, fishing effort, and catch rates, expressed as landings in bushels per hour fished were mapped at the large scale of regions, as well as the smaller scale of 10 x 10 nautical mile grids, for all years between 1982 and 2016. The distribution of catch and effort has shifted northward and there has been a noticeable decline in catch rates in the southern regions of the fishery. Commercial industry decisions to move processing facilities to areas of higher abundance appears to have been the main reason for the northward movement in fishery operations. The opinion was expressed that there may have been a distributional movement of the species northward in response to increasing temperature, but it is difficult to assess whether this is supported by the data. A dedicated survey has detected a modest shift in median depth (8 cm per year) for ocean quahog only in the NJ region. TOR 3 examined this aspect in more detail

Information from the Maine mahogany quahog fishery was also included and assessed for spatial and temporal changes, although for assessment purposes, this component was not considered as part of the federal ocean quahog resource (US EEZ Stock). The Maine quahog fishery appears to have been supported by two major pulses of recruitment some time ago, both of which have been declining over time as a result of fishing pressure.

There was some uncertainty around the estimate of discard rates, but not considered of major importance due to the small percentages in relation to retained catches. Similarly, although no estimates of recreational catch were available, the uncertainty in that catch component was considered as a non-issue due to the lack of a recreational interest in this species, and the difficulty their deep water distribution poses for access by recreational fishing vessels.

In summary, I consider the state of knowledge of total removals of quahogs, including commercial and recreational catch, incidental and discard mortality, to be well characterised with relatively little uncertainty. Effort distributions and changes over time are well understood and provide sound and credible information to aid current and future fishery management.

3.2 TOR 2: Survey data

Present the survey data being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, length data, etc.). Use logbook data to investigate regional changes in LPUE, catch and effort. Characterize the uncertainty and any bias in these sources of data. Evaluate the spatial coverage, precision, and accuracy of the new clam survey

This TOR was completed. The abundance data collected by the dredge survey is a comprehensive time series of fishery independent survey data extending back to 1982, undertaken every three years. All available data were presented, along with details of the survey methodology, the time periods which contained information, and historical summaries of prior time series, which had not been included in the current analyses. The densities in numbers per m^2 and kg per m^2 were "tabulated" and presented by individual regions with asymmetric CLs to characterise the uncertainty. Densities of individual survey tows were also graphed to give a spatial representation of the survey coverage. Regional differences exist in the survey data trends, however there is much noise in them, as well as an anomalous year (1994), which elicited some discussion. It would be unusual for an animal of this longevity to oscillate in abundance so abruptly. The panel requested a model run without the 1994 data point to examine its effect, which turned out to be negligible (see TOR 5).

Both the report and subsequent discussions with the WG confirmed that the sampling design for the ocean quahog dredge survey was considered suboptimal due to fact that it was not designed solely for this species, but also to generate an abundance index for the surf clam resource. Recent changes to the dredge design improved the efficiency (catchability) of the research dredge, and were expected to improve precision of the survey index but this did not eventuate. Also, data collected by the new dredge design (post 2011) was modelled as a new data trend, and for some regions (e.g. LI, NJ, GBK), there was a significant increase in abundance as a result. The various difficulties in interpretation sparked considerable discussions as to the nature of improvements, and many of the research recommendations were made with the goal of improving this critical index, and mitigating some of the criticisms of issues such as "data borrowing".

I particularly consider that abundance data collected by the fishery independent surveys would benefit from further investigation to ensure the best possible time series index is available for the SS3 population dynamics model. Information is available for at least an exploratory investigation. For example, the important factors which influence the dredge survey data are region, depth, speed, tow duration, and dredge characteristics (e.g., blade width, mesh liner size, differential pressure, angle of tilt). I note that that these factors have been investigated as part of the determination of selectivity and length weight relationships (Equation 1, Table 13, of the assessment report) to establish a "kg/m^2" measure, but alternative treatments of the data are possible and potentially desirable. My comments are made in light of the considerable complexity needed within the SS3 model to construct a viable abundance time series index from the survey data. This complexity involved fits to trend and scale independently for two different “dredge designs”, and multiple time series. Thus, the eventual outputs of estimated biomass and recruitment depended on the estimation of 12 parameters from the survey abundance trend, yet fits to the biomass trend were relatively poor (see TOR 5).

For example, the survey data could be modelled purely as an abundance index (say total count), standardised for the key factors of region, depth, speed, tow duration, dredge blade width, etc., but without the size-frequency data, and without needing to be corrected with a composite metric of “area swept” based on dredge type, speed and duration. This allows the quahog size-frequency distributions obtained from the dredge surveys to be a completely independent index, the shape of which can be estimated by the SS3 population model using the prior estimates for catchability, length weight parameters and growth and mortality assumptions. Careful consideration is required on this, but it may deal with the issues of data borrowing, and lack of a unified abundance index which synthesises regional variability and dredge design changes. In particular, modifications to dredge design is considered likely into the future to improve selectivity and precision, and it would be advantageous to have a method capable of integrating additional changes into the index, rather than treating each dredge design improvement as a “new data series”.

3.3 TOR 3: Habitat

Describe the relationship between habitat characteristics (e.g., benthic, pelagic, and climate), survey data, and ocean quahog distribution, and report on any changes in this relationship

This TOR was comprehensively completed. The clam survey data (TOR 2) from 1997 to 2011 provided a baseline data set of ocean quahog distribution from a period in which the dredge survey gear was consistent. A range of environmental and climate variables that included benthic indices, sediment type, SST and chlorophyll information were collated and examined for their predictive ability in describing quahog distribution over time. The predictive model was a random forest regression tree model. It was conditioned on 70% of the survey abundance data, and the remaining 30% used to test its predictive ability. The explanatory variables adequately described the distribution of quahogs, without recourse to spatial information such as latitude and longitude. This is a strength, as it shows that model inferences were based on actual habitat characteristics rather than geographic proxies. The analysis supported the temporal shifts in ocean quahog distribution recently addressed as part of the surf clam assessment (SARC/SAW 61, NEFSC 2017).

The fits of the regression trees to the survey data was good, with the exception of some unexplained variation at the higher end. This may benefit from further exploration as it suggests the highest density areas are not relatively well understood by the model. The WG did explore alternative transformations to the data, but none of these improved the residual diagnostics or the model fits. Higher density sites are likely to be significant to the stock as important breeding areas and significant to the fishery as areas of high commercial value, so it is important their distribution is understood. On the positive side, the WG concluded that the model predicts fine-scale variability not evident in the original data, and future work will determine the usefulness of these predictions in detecting fishable ocean quahog beds.

The background literature indicates that ocean quahog is to a large extent buffered from climate variability by its preferred habitat in deeper areas bounded by the 16°C thermal isocline. Previous modelling by the NEFSC showed that there was a modest shift in median depth in the New Jersey region, however no other changes in distribution of ocean quahogs were noted between 1982 and 2011. It was acknowledged that ocean acidification could be an issue, but is likely to affect recruitment more than natural mortality. This is because the larval stage of the molluscan life cycle is considered to be the most vulnerable to ocean acidity effects.

3.4 TOR 4: Growth

Evaluate age determination methods and available data for ocean quahogs to potentially estimate growth, productivity, and recruitment. Review changes over time in biological parameters such as length, width, and condition.

This TOR was completed. The assessment report noted that relatively little growth information was available, and a considerable effort was made to model growth accurately to a range of growth models with different assumptions. Annual growth rings are detectable in ocean quahog and were used for the assessment, despite concerns about the difficulty of aging older quahogs and data suggesting growth had varied significantly in the Georges Bank region. During the workshop, the panel was shown the latest findings from the image analysis software used to enumerate growth rings by Roger Mann from the Virginia Institute of Marine Science. This suggested the possibility of also detecting daily rings in smaller quahogs.

New growth data and alternative growth models were investigated, however the WG noted that the stock assessment models for ocean quahog used in the assessment (SS3 and KLAMZ) are not flexible enough to accommodate the "Tanaka" growth model. It was possible to approximate non-asymptotic growth to a limited extent in SS3 so a sensitivity analysis was undertaken on the "Tanaka-pattern" for growth, with the main management advice being based on the traditional von Bertalanffy results. This is a sensible first step in balancing the need for the most appropriate growth model within the constraints of the SS3 modelling platform.

The rationale behind the use of the growth models was well presented and the substantial issue of non-asymptotic growth was identified as a key area for further investigation. Panel members exchanged manuscripts which detailed development of non-asymptotic growth models for invertebrate species to the WG members for their consideration. If the SS3 programming environment continues to be used however, developmental work on the code within SS3 may be required to allow the use of parameters from a non-asymptotic growth model.

Morphological metrics were analysed and modelled for year and regional effects. Regional differences in morphology were observed, but found to be minor. Temporal changes were not observed and it was unlikely that major changes in the condition of ocean quahogs had occurred, given these results.

The validated age data on five individuals showed that variable growth was likely, which may lead to possible differences in productivity between regions. This possibility needs to be explored in future assessments, as the ageing method develops, particularly in the Georges Bank region, for which preliminary data suggested an 80 mm animal could be anywhere between 30 and 90 years of age.

3.5 TOR 5: Model

Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR 4, as appropriate) and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results and previous projections

This ToR was met. There are however, substantial challenges in modelling a very low level of fishing mortality on a long-lived animal. The near absence of a signal in the abundance or size-structure information makes it difficult to estimate true biomass or recruitment of the population. Nevertheless, the approach taken was comprehensive and results as definitive as they could be, given the circumstances.

The principal model used in the assessment was an integrated statistical catch-at-age model implemented in the software package Stock Synthesis III (SS3), with the previous biomass dynamics model (KLAMZ) used in the sensitivity analysis. The SS3 model is an appropriate choice for this assessment as it allows all available information to be integrated. The model was split into separate areas for Georges Bank (North) and other areas (South), and the results were combined within the model to provide management advice for the assumed stock. There was a consensus that this is a good structure for the model and overcomes some of the difficulties inherent in combining the results from multiple models. The catch rate data were not used in the assessment because the fleet targets only a small proportion of the total stock and the spatial location of the areas targeted had changed over the history of the fishery in response to declines in LPUE. This decision sparked robust discussion about the scale of the assessment versus the scale of depletion. My opinion is that the potential for localised depletion is low, given that, with current fishing effort, the rotational period for revisiting previously fished sites is likely to be in the multiples of decades. However, it would be a sensible practice to re-visit the possibility of using LPUE as an abundance index at every major assessment to ensure the spatial mismatch issue is not discounted.

The final model chosen for the assessment was called BASE8, which hinted at a development trajectory prior to the chosen configuration. Understanding this model selection process provides the rationale for a myriad of decisions on model structure or data, and is usually helpful for a robust review of the assessment decisions. In this case however, the assessment report was clear about the difficulty in finding congruence between the dynamics of ocean quahog and the variance in the survey data, and presented three approaches (two model-based and one empirical) to estimating biomass. I consider the BASE8 model to be a reasonable choice, although not likely to be the only possible model. It would have been helpful to see the population dynamics in their equation form (as an Appendix) as the order in which each model step taken is usually important in determining the likelihoods of the final fit. The level of detail provided at the SARC was sufficient, but an equation Appendix is essential in an assessment report of a population dynamics model.

Give the issues identified above, the SS3 model relied heavily on prior information for catchability and selectivity from the different dredge types to help it converge on relatively stable solutions. In essence, these priors determined the scale of the biomass, and therefore the important virgin recruitment (R_0) parameter. This resulted in good fits to the length composition data, but poor fits to the biomass index. At least one of the survey data points (for the southern area in 1994) is anomalous and probably biased by changes to survey gear performance in that year. The panel requested a sensitivity run without the 1994 dataset during the SARC workshop; its exclusion was found to have little effect on the biomass outputs, which again highlights the problem of a very low F that has negligible influence on trend. A statistical reanalysis of the dredge survey dataset in the manner proposed in TOR 2 could shed light on the 1994 anomaly, although information on some explanatory variables might not be available back to 1994.

Due to the long-term nature of the ocean quahog dynamics, and the problem of accounting for such a low F, the relatively poor fit to the biomass indices in the base model was acceptable and understandable for this species. Potential data integrity issues such as non-completion of surveys within a calendar year, or "data borrowing" for un-sampled strata among adjacent surveys are unlikely to be relevant for this assessment. However, improving the utility of the biomass surveys to inform the stock assessment model should be a priority area of research, particularly given the importance of selectivity parameters in facilitating a sensible model fit. Attempts to improve selectivity (i.e. lower the L_{50}) in order to detect younger age classes should be considered, alongside analysis suggestions as provided under TOR 2.

Parameters estimates were presented as those at the maximum of the posterior density (MPD) and their uncertainties were estimated from the model's Hessian matrix. This is an approximate method for a Bayesian model and it would have been better to estimate the Bayesian posterior distributions of estimated and derived parameters using Markov chain Monte Carlo (MCMC) methods. As well as providing better estimates of uncertainty (and correlation between parameters), MCMCs are particularly useful for diagnosing some problems in model convergence or stability, and in providing for stochastic projections. Running MCMCs can be time-consuming, and model development is almost always conducted using MPD fits, but the MCMC(s) are considered the norm for a Bayesian assessment model. If there are software or other impediments to running MCMCs routinely, these should be tackled as a priority.

The scale of absolute abundance (and, hence, fishing mortality) was somewhat uncertain in the model, but trends in relative biomass and fishing mortality were much more certain. A wide range of sensitivity analyses were conducted, including the use of a different assessment model (KLAMZ) as well as an empirical approach. Agreement among these supported the model-estimated trends, and the working group's conclusions from the model were robust to many of the modelling choices.

The assessment of stock status focused on trends and ratios, as opposed to actual biomass of fishing mortality estimates. This was appropriate for the following reasons. First, as mentioned previously, the priors on survey catchability (*q*) heavily influenced the scale of the estimate, yet there was a substantial possibility that *q* from the survey and depletion experiments were different. This mismatch is mostly likely due to the physical changes to the quahog habitat when impacted by the dredge in multiple passes during the depletion experiment. These changes are presumed to expose the deeply-buried quahogs which would otherwise never be caught during the single pass of a dredge in a normal survey. Second, sensitivity and retrospective analyses show that the model's estimates of trends in biomass and fishing mortality were much more stable, and therefore more credible as a basis for developing fishery management advice, than the estimates of absolute values.

A substantial positive recruitment deviation was estimated by the SS3 model in the late 1990s. This appeared to be caused by the size frequency and survey data abundances, coupled with the growth model, which forced the SS model to estimate a large recruitment spike during this period. I consider this estimate to be quite uncertain, and not to be considered a reliable estimate, as it could affect the projections if the stock got near the threshold reference point.

3.6 TOR 6: Reference Points

State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, FMSY and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

This ToR has been comprehensively met. The existing biological reference points (BRPs) for ocean quahog were based on long-lived finfish proxy for $F_{\text{Threshold}}$ ($F_{45\%}$ for rockfish = 0.022), and expert opinion for $SSB_{Threshold}$ (= 0.4*B_{1978}). They were considered arbitrary and a decision was made to develop BRPs based on fishery performance criteria that accounted as much as possible, for the peculiar dynamics of ocean quahog. The most appropriate methodology for undertaking this is a management strategy evaluation (MSE). This allows for identification of robust reference points that work well across a range of potential spawner recruit curves and life-history patterns. MSEs were tailored to ocean quahog dynamics, including different assumptions about growth, in particular, asymptotic vs non-asymptotic growth trajectories. They also simulated the response of the ocean quahog stock to a harvest control rule that was tailored to match the peculiarities of management and quota setting in this fishery. Most importantly, the recommended new BRPs were based on meaningful estimates of their uncertainty evaluated within the MSE, and were thus considered superior to the previous BRPs. The approach was entirely credible and provides a sound basis for the provision of management advice.

The biomass target (0.5*B_0) and biomass threshold (0.4*B_0) were close in scale. Under US legislation, this could trigger a rebuilding plan quite soon after the biomass declined below its B_{MSY} target. I consider this proximity between target and threshold BRPs to only be theoretically problematic and resource intensive for the management process, as biomass would need to decline substantially below its current high level to cause a substantial management response to be implemented. This appears to be highly unlikely under current levels of fishing. With respect to the conservative biomass threshold of 0.4*B_0, my opinion is that it is scientifically defensible for an animal of such low productivity and an appropriate metric for management. These matters ought to be considered by the relevant decision-making groups when BRPs are next reviewed for ocean quahog.

3.7 TOR 7: Stock status

Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to any new model or models developed for this peer review.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-6).

This ToR was met in full. Stock status was determined as the ratio of the current F and biomass estimates to their respective BRPs. This was carried out using the old biomass dynamics model (KLAMZ), and the newly developed SS3 assessment models. The comparison was required as it allowed for a definitive statement about the effect of changing the BRPs and the models used to assess stock status. These types of evaluations are necessary for ensuring consistency and integrity in the assessment process over the long-term.

All of the analyses that were conducted indicated that the stock was not overfished nor was experiencing overfishing. This result was consistent across sensitivity runs. MSY was estimated at 60,000 tonnes, and current catch is significantly below this.

These status determinations were carried out appropriately, including dealing with the change in biomass units from fishable biomass in the KLAMZ model to spawning stock biomass (SSB) in the SS3 model. In all cases, and across a comprehensive set of sensitivity runs, the outcomes were consistent in indicating that the stock was neither overfished nor experiencing overfishing.

3.8 TOR 8: Projections

Develop approaches and apply them to conduct stock projections.

a. Provide numerical annual projections (5 – 50 years) and the statistical distribution (e.g., probability density function) of the OFL (overfishing level), including model estimated and other uncertainties. Consider cases using nominal as well as potential levels of uncertainty in the model. Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

c. Describe this stock's vulnerability (see "Clarification of Terms used in the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

I considered this TOR to be satisfactorily completed. Projections of stock biomass were made for the years 2017 to 2066 based on three different harvest policies that encompassed the range between expected and maximum sustainable landings from the fishery. Assumptions about the likely level of average recruitment, based on the uncertainty in the 2017 estimated biomass, were considered sensible and realistic for this analysis. The panel also requested that an extra projection for zero recruitment over the projection period be incorporated as part of the sensitivity analysis. This was completed by the WG during the SARC meeting.

Projections indicated that biomass will remain above the threshold, for the entire resource, including the scenario of $F = F_{Threshold}$ (OFL Catch). The sensitivity analysis was comprehensive, using different growth models, mortality, and recruitment assumptions to derive both point and cumulative probability estimates of overfishing. Distributions of biomass assumed lognormal and variances equal to delta method variances, and one million draws were taken from these distributions to investigate the projection scenarios. The status of each performance indicator for the resource, i.e., the $SSB/SSB_{Threshold}$ and $F/F_{Threshold}$ ratios, were shown for all projection years, and all sensitivity scenarios.

Projections showed unequivocally that biomass had no probability of reaching the threshold level, even when F was set at the threshold level, and recruitment was set to 0. This shows that the stock's vulnerability to overfishing is exceedingly low, even under the less conservative assumptions about F. Therefore, it is likely to be relatively insensitive to the choice of ABC (Acceptable Biological Catch) for this resource.

It was noted that the key assumption in the projections is no changes in the market conditions (demand curve for ocean quahog) would occur. In the unlikely event of a major increase in demand for this species, the projections have provided a solid baseline of scenarios to inform any radical proposals for a change in harvest policy.

3.9 TOR 9: Research recommendations

Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports. Identify new research recommendations

This ToR was met in full. Progress was noted against 21 research recommendations from the previous assessment (SARC 48), and a list of 14 additional recommendations was compiled.

Nine out of the 21 existing recommendations were reported as having been completed. These included changes to the survey, estimation of survey selectivity and catchability, development of a length-structured model, and simulation modelling to determine proxy MSY reference points. One recommendation was dropped as being no longer relevant; this related to the previous survey platform. Significant and ongoing progress was reported for seven recommendations. These related to age and growth studies, maturity, investigation of spatial structure and incorporation into assessment models, survey design and evaluation of the use of underwater photography to survey ocean quahog. No progress was noted for four recommendations, relating to fecundity at size, the relationship of dredge efficiency with depth, ocean quahog density and substrate type and incorporation of size-selectivity in the Patch depletion model.

I consider that significant progress has been made against these recommendations, and these have had a positive impact on the assessment, including the model, survey and the biological parameters and data that underpin these. In relation to the mismatch of spatial scale identified between the assessment and ocean quahog demographic processes, several ongoing research recommendations are addressing the issue, and further research action against these should be a high priority. Other priorities for outstanding research recommendations should be improved estimation of biological parameters and further understanding of survey dredge efficiency in relation to ocean quahog density and bottom type.

The Panel also endorsed the list of new research recommendations, particularly in relation to growth and age determination, spatial processes and recruitment processes. During the meeting an informally rationalized and prioritized list of research recommendations was compiled by the WG Chair, at the request of the Panel. Recommendations were grouped into age and growth, survey and fishery topics, roughly prioritized. There was not the opportunity for a full discussion during the meeting, but the Panel agreed that the list provides an effective basis for further discussion on priorities within the WG. Again, the panel identified survey performance, age and growth, spatial processes and recruitment processes as areas that do need attention.

4 Appendices

4.1 Appendix 1: Bibliography of background materials provided for review

Chute A, Hennen D, Russell R, Jacobson L. 2013. Stock Assessment Update for Ocean Quahogs (***Arctica islandica***) through 2011. NEFSC Ref Doc 13-17; 156 p.

Harding JM, King SE, Powell EN, Mann R. 2008. Decadal Trends in Age Structure and Recruitment Patterns of Ocean Quahogs (*Arctica islandica)* from the Mid-Atlantic Bight in Relation to Water Temperature. Journal of Shellfish Research 27(4): 667-690.

Hennen DR. 2015. How Should We Harvest an Animal That Can Live for Centuries? North American Journal of Fisheries Management 0: 1-16.

Hennen D, Jacobson L, and Tang J. 2012. Accuracy of the Patch model used to estimate density and capture efficiency in depletion experiments for sessile invertebrates and fish. ICES Journal of Marine Science 69: 240–249.

Kilada, R. W., Campana S. E., and Roddick, D. 2007. Validated age, growth, and mortality estimates of the ocean quahog (*Arctica islandica*) in the western Atlantic. ICES Journal of Marine Science 64: 31–38.

Murawski SA, Ropes JW, Serchuk FM. 1982. Growth of the Ocean Quahog, *Arctica islandica*, in the Middle Atlantic Bight. Fish Bull 80:1; 14 p.

Northeast Fisheries Science Center. 2009. 48th Northeast Regional Stock Assessment Workshop (48th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc 09-15; 834 p.

Northeast Fisheries Science Center. 2009. 48th Northeast Regional Stock Assessment Workshop (48th SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc 09-10; 50 p.

Rago PJ, Weinberg JR, Weidman C. 2006. A spatial model to estimate gear efficiency and animal density from depletion experiments. Can J Fish Aquat Sci 63: 2377-2388.

Ridgway ID, Richardson CA. 2011. *Arctica islandica*: the longest lived non colonial animal known to science. Rev Fish Biol Fisheries 21: 297-310.

Thorarinsdottir GG, Jacobson LD. 2005. Fishery biology and biological reference points for management of ocean quahogs (*Arctica islandica*) off Iceland. Fisheries Research 75: 97-106.

Witbaard, R. 1996. Growth variations in *Arctica islandica* L. (Mollusca): a reflection of hydrography-related food supply. ICES Journal of Marine Science 53: 981–987.

Working Papers

Working Group, Stock Assessment Workshop (SAW 63) 2017. Stock Assessment Report of Ocean Quahog. SAW/SARC 63. February 21-23, 2017. NOAA Fisheries, Northeast Fisheries Science Center. Woods Hole, MA. 404p.

Working Group, Stock Assessment Workshop (SAW 63) 2017. Stock Assessment Summary Report of Ocean Quahog. SAW/SARC 63. February 21-23, 2017. NOAA Fisheries, Northeast Fisheries Science Center. Woods Hole, MA. 10p.

Working Group, Stock Assessment Workshop (SAW 63). 2017. Term of Reference 9 – Revised Research Recommendations. 2p.

Presentations

Working Group, Ocean Quahog. 2017. Ocean Quahog Assessment 2017. PowerPoint presentation. 90 slides.

4.2 Appendix 2: CIE Statement of Work

Statement of Work

National Marine Fisheries Service (NMFS)

Center for Independent Experts (CIE) Program

External Independent Peer Review

63rd Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) Benchmark stock assessment for Ocean quahog

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).
Further information may be obtained from www.ciereviews.org.

Scope

The Northeast Regional Stock Assessment Review Committee (SARC) meeting is a formal, multiple-day meeting of stock assessment experts who serve as a panel to peer-review tabled stock assessments and models. The SARC peer review is the cornerstone of the Northeast Stock Assessment Workshop (SAW) process, which includes assessment development, and report preparation (which is done by SAW Working Groups or ASMFC technical committees), assessment peer review (by the SARC), public presentations, and document publication. This review determines whether or not the scientific assessments are adequate to serve as a basis for developing fishery management advice. Results provide the scientific basis for fisheries within the jurisdiction of NOAA's Greater Atlantic Regional Fisheries Office (GARFO).

The purpose of this meeting will be to provide an external peer review of a benchmark stock assessment for **Ocean quahog**. The requirements for the peer review follow. This Statement of Work (SOW) also includes Appendix 1: TORs for the stock assessment, which are the responsibility of the analysts; Appendix 2: a draft meeting agenda; Appendix 3: Individual Independent Review Report Requirements; and Appendix 4: SARC Summary Report Requirements.

Requirements

NMFS requires three reviewers under this contract (i.e. subject to CIE standards for reviewers) to participate in the panel review. The SARC chair, who is in addition to the three reviewers, will be provided by either the New England or Mid-Atlantic Fishery Management Council's Science and Statistical Committee; although the SARC chair will be participating in this review, the chair's participation (i.e. labor and travel) is not covered by this contract.

Each reviewer will write an individual review report in accordance with the SOW, OMB Guidelines, and the TORs below. All TORs must be addressed in each reviewer's report. No more than one of the reviewers selected for this review is permitted to have served on a SARC panel that reviewed this same species in the past. The reviewers shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise should include forward projecting statistical catch-at-age models. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers should have experience in development of Biological Reference Points (BRPs) that includes an appreciation for the varying quality and quantity of data available to support estimation of BRPs. For ocean quahogs (a bivalve), knowledge of long-lived, sedentary invertebrates would be useful.

Requirements for Reviewers

- Review the background materials and reports prior to the review meeting
- Attend and participate in the panel review meeting
    - The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
- Reviewers shall conduct an independent peer review in accordance with the requirements specified in this SOW and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.
- Each reviewer shall assist the SARC Chair with contributions to the SARC Summary Report
- Deliver individual Independent Review Reports to the Government according to the specified milestone dates
- This report should explain whether each stock assessment Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified below in the "Requirements for SARC panel."
- If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.
- During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent Report produced by each reviewer.
- The Independent Report can also be used to provide greater detail than the SARC Summary Report on specific stock assessment Terms of Reference or on additional questions raised during the meeting.

Requirements for SARC panel

- During the SARC meeting, the panel is to determine whether each stock assessment Term of Reference (TOR) of the SAW was or was not completed successfully. To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. If alternative assessment models and model assumptions are presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. Where possible, the SARC chair shall identify or facilitate agreement among the reviewers for each stock assessment TOR of the SAW.

- If the panel rejects any of the current BRP or BRP proxies (for B_{MSY} and F_{MSY} and MSY), the panel should explain why those particular BRPs or proxies are not suitable, and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs or BRP proxies are the best available at this time.
- Each reviewer shall complete the tasks in accordance with the SOW and Schedule of Milestones and Deliverables below.

Requirements for SARC chair and reviewers combined:

Review both the Assessment Report and the draft Assessment Summary Report. The draft Assessment Summary Report is reviewed and edited to assure that it is consistent with the outcome of the peer review, particularly statements that address stock status and assessment uncertainty.

The SARC Chair, with the assistance from the reviewers, will write the SARC Summary Report. Each reviewer and the chair will discuss whether they hold similar views on each stock assessment Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this SARC Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion. The SARC Summary Report will not be submitted, reviewed, or approved by the Contractor.

If any existing Biological Reference Points (BRP) or BRP proxies are considered inappropriate, the SARC Summary Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRP proxies are the best available at this time.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, country of birth, country of citizenship, country of permanent residence, country of current residence, dual citizenship (yes, no), passport number, country of passport, travel dates.) to the NEFSC SAW Chair for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be at the contractor's facilities, and at the Northeast Fisheries Science Center in Woods Hole, Massachusetts.

Period of Performance

The period of performance shall be from the time of award through April 7, 2017. Each reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

No later than January 17, 2017	Contractor sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
No later than February 7, 2017	NMFS Project Contact will provide reviewers the pre-review documents
Feb. 21 - 23, 2017	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
February 23, 2017	SARC Chair and reviewers work at drafting reports during meeting at Woods Hole, MA, USA
March 9, 2017	Reviewers submit draft independent peer review reports to the contractor's technical team for review
March 9, 2017	Draft of SARC Summary Report, reviewed by all reviewers, due to the SARC Chair *
March 16, 2017	SARC Chair sends Final SARC Summary Report, approved by reviewers, to NMFS Project contact (i.e., SAW Chairman)
March 23, 2017	Contractor submits independent peer review reports to the COR and technical point of contact (POC)
March 30, 2017	The COR and/or technical POC distributes the final reports to the NMFS Project Contact and regional Center Director

* The SARC Summary Report will not be submitted to, reviewed, or approved by the Contractor.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards:

(1) The reports shall be completed in accordance with the required formatting and content;
(2) The reports shall address each TOR as specified;

(3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $20,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contact

Dr. James Weinberg, NEFSC SAW Chair

Northeast Fisheries Science Center

166 Water Street, Woods Hole, MA 02543

James.Weinberg@noaa.gov Phone: 508-495-2352

Appendix 1. ***Stock Assessment Terms of Reference for SAW/SARC-63***

The SARC Review Panel shall assess whether or not the SAW Working Group has reasonably and satisfactorily completed the following actions.

A. Ocean quahog

1. Estimate catch from all sources including landings and discards. Map the spatial and temporal distribution of landings, discards, and fishing effort, as appropriate. Characterize the uncertainty in these sources of data.

2. Present the survey data being used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, length data, etc.). Use logbook data to investigate regional changes in LPUE, catch and effort. Characterize the uncertainty and any bias in these sources of data. Evaluate the spatial coverage, precision, and accuracy of the new clam survey.

3. Describe the relationship between habitat characteristics (e.g., benthic, pelagic, and climate), survey data, and ocean quahog distribution, and report on any changes in this relationship.

4. Evaluate age determination methods and available data for ocean quahogs to potentially estimate growth, productivity, and recruitment. Review changes over time in biological parameters such as length, width, and condition.

5. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR 4, as appropriate) and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results and previous projections.

6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

7. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to any new model or models developed for this peer review.

    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-6).

8. Develop approaches and apply them to conduct stock projections.

    a. Provide numerical annual projections (5 – 50 years) and the statistical distribution (e.g., probability density function) of the OFL (overfishing level), including model estimated and other uncertainties. Consider cases using nominal as well as potential levels of uncertainty in the model. Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
    c. Describe this stock's vulnerability (see "Clarification of Terms used in the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports. Identify new research recommendations.

Clarification of Terms used in the Stock Assessment Terms of Reference

Guidance to SAW WG about "Number of Models to include in the Assessment Report":

In general, for any TOR in which one or more models are explored by the WG, give a detailed presentation of the "best" model, including inputs, outputs, diagnostics of model adequacy, and sensitivity analyses that evaluate robustness of model results to the assumptions. In less detail, describe other models that were evaluated by the WG and explain their strengths, weaknesses and results in relation to the "best" model. If selection of a "best" model is not possible, present alternative models in detail, and summarize the relative utility each model, including a comparison of results. It should be highlighted whether any models represent a minority opinion.

On "Acceptable Biological Catch" (DOC Nat. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):

Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of Overfishing Limit (OFL) and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*

ABC for overfished stocks. For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)

ABC refers to a level of ‘‘catch’’ that is ‘‘acceptable’’ given the ‘‘biological’’ characteristics of the stock or stock complex. As such, Optimal Yield (OY) does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

On “Vulnerability” (DOC Natl. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):

“Vulnerability. A stock’s vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce Maximum Sustainable Yield (MSY) and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality).” (p. 3205)

Participation among members of a Stock Assessment Working Group:

Anyone participating in SAW meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Appendix 2. Draft Review Meeting Agenda

{Final Meeting agenda to be provided at time of award}

63rd Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) Benchmark stock assessment for A. Black sea bass and B. Witch flounder

February 21-23, 2017

Stephen H. Clark Conference Room – Northeast Fisheries Science Center

Woods Hole, Massachusetts

DRAFT AGENDA* (version: Aug. 23, 2016)

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

Tuesday, Feb. 21

10 – 10:30 AM

Welcome	**James Weinberg**, SAW Chair		
Introduction	**Edward Houde,** SARC Chair		
Agenda			
Conduct of Meeting			

10:30 – 12:30 PM Assessment Presentation (A. Ocean quahog)

	Dan Hennen		**TBD**

12:30 – 1:30 PM Lunch

1:30 – 3:30 PM Assessment Presentation (A. Ocean quahog)

Dan Hennen **TBD**

3:30 – 3:45 PM Break

3:45 – 5:45 PM SARC Discussion w/ Presenters (A. Ocean quahog)

Ed Houde , SARC Chair **TBD**

5:45 – 6 PM Public Comments

7 PM **(**Social Gathering**)**

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

<u>Wednesday, Feb. 22</u>

9:00 – 10:45 Revisit with Presenters (A. Ocean quahog)

Ed Houde, SARC Chair **TBD**

10:45 - 11 Break

11 – 11:45 Revisit with Presenters (A. Ocean quahog)

Ed Houde , SARC Chair **TBD**

11:45 – Noon Public Comments

12 – 1:15 PM Lunch

1:15 – 4 Review/Edit Assessment Summary Report (A. Ocean quahog)

Ed Houde , SARC Chair **TBD**

4 – 4:15 PM Break

4:15 – 5:00 PM SARC Report writing

<u>Thursday, Feb. 23</u>

9:00 AM – 5:00 PM SARC Report writing

*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public; however, during the Report Writing sessions on July 20 and 21, we ask that the public refrain from engaging in discussion with the SARC.

Appendix 3. Individual Independent Peer Review Report Requirements

1. The independent peer review report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs. The independent report shall be an independent peer review, and shall not simply repeat the contents of the SARC Summary Report.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the SARC Summary Report that they believe might require further clarification.

   d. The report may include recommendations on how to improve future assessments.

3. The report shall include the following appendices:

Appendix 1: Bibliography of materials provided for review

Appendix 2: A copy of this Statement of Work

Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Appendix 4. SARC Summary Report Requirements

1. The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background and a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether or not each Term of Reference of the SAW Working Group was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

   To make this determination, the SARC chair and reviewers should consider whether or not the work provides a scientifically credible basis for developing fishery management advice. If the reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

   The report may include recommendations on how to improve future assessments.

2. If any existing Biological Reference Points (BRPs) or BRP proxies are considered inappropriate, include recommendations and justification for alternatives. If such alternatives cannot be identified, then indicate that the existing BRPs or BRP proxies are the best available at this time.

3. The report shall also include the bibliography of all materials provided during the SAW, and relevant papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

   The report shall also include as a separate appendix the assessment Terms of Reference used for the SAW, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

4.3 Appendix 3: Panel Membership

SAW 63 Working Group Members and Attendees at the SARC 63 Panel Meeting

NAME	AFFILIATION	EMAIL
Ed Houde	U Maryland Center for Environmental Science	ehoude@umces.edu
Anthony Hart	Western Australian Fisheries	Anthony.Hart@fish.wa.gov.au
Mike Bell	Heriot-Watt University – Intl Centre for Island Tech	M.C.Bell@hw.ac.uk
Martin Cryer	Ministry for Primary Industries, Wellington	Martin.Cryer@mpi.govt.nz
Russ Brown	NEFSC	Russell.brown@noaa.gov
Jim Weinberg	NEFSC	james.weinberg@noaa.gov
Larry Jacobson	NEFSC	larry.jacobson@noaa.gov
Dan Hennen	NEFSC	Daniel.hennen@noaa.gov
Jessica Coakley	MAFMC	jcoakley@mafmc.org
Chris Legault	NEFSC	chris.legault@noaa.gov
Sheena Steiner	NEFSC	sheena.steiner@noaa.gov
Alicia Miller	NEFSC	alicia.miller@noaa.gov
Toni Chute	NEFSC	toni.chute@noaa.gov
Mark Terceiro	NEFSC	mark.terceiro@noaa.gov
José Montañez	MAFMC	jmontanez@mafmc.org
Joe Myers	Bumble Bee/Snow's Foods	joseph.myers@bumblebee.com
Tom Hoff	Wallace & Associates	tbhoff@verizon.net
Daphne Munroe	Rutgers University	dmunroe@hsrl.rutgers.edu
Tom Alspach	Sea Watch International	talspach@goeaston.net
Eric Powell	University of Southern Mississippi	eric.n.powell@usm.edu
Roger Mann	VIMS	rmann@vims.edu
D.H. Wallace	Wallace & Associates	DHWallace@aol.com
Doug Potts	NMFS/GARFO	douglas.potts@noaa.gov
Gary Shepherd	NEFSC	gary.shepherd@noaa.gov